THE

AMERICAN JOURNAL

OF THE MEDICAL SCIENCES.

JANUARY, 1896.

TRICHOMONAS AS A PARASITE OF MAN.*

By George Dock, A.M., M.D.,

PROFESSOR OF MEDICINE IN THE UNIVERSITY OF MICHIGAN, ANN ARBOR, MICH.

In 1836 Donné[1] found a previously undescribed parasite in the vaginal secretions of women. These were described as roundish bodies about twice the size of pus corpuscles and difficult to distinguish from the latter except by their independent motion. The motion was produced by certain organs, viz., a flagelliform appendage at the anterior end which worked with great rapidity, and a row of short cilia, at one side and near the flagellum, which kept up a sort of rotary motion. At the posterior end was a tail-like appendage of variable shape (Fig. 18). On account of the fact that the parasite resembled monads in having a flagellum, and "trichodines" (ciliata) in having cilia, Donné gave it the name of trichomonas, with the specific name *vaginale* on account of the habitat. Although there were errors in Donné's description, it was remarkably good considering the methods of observation and the knowledge of micro-parasites then available. Certain details in the description will be mentioned later. Notwithstanding Donné's growing reputation as a microscopist, and the fact that his observations were controlled by such men as Dujardin, Milne-Edwards, Ricord, and others,[1] many microscopists (Vogel, Siebold, Valentin) denied the parasitic nature of the bodies, and held them to be altered epithelial cells from the uterus. Later, however, Scanzoni and Kölliker,[2] Hennig,[3] Haussmann,[4] and Gasser[5] re-examined the organisms, mostly from the side of clinical microscopy. Still later Künstler[6] and Henneguy, in France,[7] and Blochman,[8] working under Bütschli, in Germany,[9] made investigations in the biology of the organisms, which, while differing in many respects, have added considerably to our knowledge. Within the last year Marchand[10] has examined the parasites with results to be mentioned later.

---

* Read before the Pathological Society of Philadelphia, April 25, 1895.

On the whole, the parasites have been deemed of so little importance that scant notice is given them. The descriptions in most text-books on gynecology, microscopy, and pathology are inadequate or erroneous, and the same is true even of some recent works on animal parasites.

An extensive but necessarily incomplete search of the American literature fails to reveal any reference to the occurrence of trichomonas vaginalis in this country. I have found it once only in the vaginal secretions of a pregnant woman in Galveston, Texas. Since my interest in the matter has been excited I have looked for it, but without success. This may be explained partly by the small number of persons examined, partly by the cleanliness of the subjects and the almost universal use of douches—the organisms being very sensitive to cold water.

Since the discovery of Donné, zoölogists have found parasites of the same kind, or closely related, in snails, frogs, ducks, etc.[11,12,13,14] With the exception of Stein, however, none of these writers have influenced the study of the human parasite.

Flagellate organisms have been observed in stools since an early period. In many cases the organisms belonged to the kind first described by Davaine,[15] who found them in cholera and typhoid fever, and named by him cercomonas hominis. The efforts of some writers to deny the existence of these bodies, or to identify them with trichomonas, have not met with entire success. I[16] have encountered this same parasite in amœbic dysentery and typhoid fever and agree with Leuckart when he says that Davaine's observation, though one of the oldest, is still one of the best and most accurate. The same organisms have been found by Ekecrantz,[17] Tham,[18] Cunningham,[19] Grassi,[20] von Jaksch,[21] Müller,[22] Massiutin,[23] Kartulis,[24] Cahen,[25] Lutz,[26] Councilman and Lafleur,[27] Schuberg,[28] and others.* This parasite has to be considered at many points in studying trichomonas, as we shall see. We must leave it now to take up the history of some intestinal flagellates more closely related to the latter.

In 1875 Marchand[31] found large numbers of infusoria in the evacuations of a case of typhoid fever. He thought they might have been the same as those of Davaine and Lambl, but they had cilia, which the earlier observers did not mention, but had no flagellum as had Davaine's organism. The flagellum, however, Marchand thought might be extremely hard to see.

---

* The parasites found by Lambl[29] in the stools of children, and often spoken of as cercomonads, were really of a different genus, Megastoma or Lamblia. (Cf. Braun, 49, p. 111.) Lambl's cercomonas from the liver[30] cannot be definitely placed; at all events it does not require further consideration now.

Soon after Zunker,[32] in the course of systematic examinations of stools, found parasites like those of Davaine in two cases and in seven others another form, which he thought similar to that found by Marchand. The description and the figures in this report differ from those of Marchand, and yet any one familiar with such organisms will admit that it is possible both Marchand and Zunker found the same organism. Based on these two reports, the accuracy of which he doubted in some particulars, Leuckart erected the species trichomonas intestinalis, which has since been accepted by some others.[33]

Grassi (*loc. cit.*) found parasites which he considered identical with cercomonas Davaine and trichomonas intestinalis Leuckart, and placed these together in a genus named by him monocercomonas. It is almost certain that some of Grassi's organisms belong to trichomonas intestinalis Leuckart, and differ considerably from cercomonas.

Under the novel name of cercomonas coli hominis May[34] described an organism discovered in the stools of a patient with carcinoma of the stomach and chronic intestinal catarrh. This, also, from the description and figures (see Figure 23 of this article) appears to be a trichomonas, and Schuberg is, no doubt, right in saying that it is one. Why he gave it the new name May does not say.

Roos[35] found flagellate parasites in the stools in a number of cases, and supposed they represented a number of distinct varieties, some being like those of Davaine, others like those of Marchand, others still like those of Zunker, and, again, after reading May's article, like the bodies described by that observer. This seems to have been caused by an indistinct knowledge of what the earlier observers had described. Some of Roos's figures represent typical trichomonads; his Figure 5, for example, is almost precisely like Miura's Figure 2 of the trichomonas found in the urethra, yet Roos calls this cercomonas Davaine. Altogether, the *naïveté* of the account is remarkable.

Epstein[36] has made extensive observations on flagellate protozoa found in the stools in twenty-six cases of infantile diarrhœa. Although Professor Hatschek determined these to belong to the genus monocercomonas Grassi, the full description and the figures in Epstein's excellent paper show certain differences as compared with those of Grassi. As the parasites seem common in Prague, we can, no doubt, expect further valuable results from their study in future. Some important clinical and pathological data of Epstein's will be mentioned later.

This short summary includes all the material available regarding flagella in the human intestines or their excretions. Diverse and often contradictory as the original documents often are, a careful study of them makes it certain that some species of trichomonas, or, in other words, some organisms closely related to the parasites so named by

Donné, are parasites at times in the human intestine. A consideration of the possible effects of the organisms must be postponed.

Organisms identical with some of those just mentioned (cercomonas mostly) have been found in the mouth (Steinberg, quoted by Leuckart, *loc. cit.*, p. 304); in abscess of the tonsil (Lenhartz[37]); in the nose (*ibid.*); in gangrene of the lung and in pleurisy (Kannenberg,[38, 39] Streng,[40] Litten,[41] Lenhartz, *loc. cit.*; and Roos, *loc. cit.*). Important in connection with the subject of flagellate parasitism, these reports are not of a kind to detain us longer at this time.

Observations on flagellates in the urine or bladder are few, but of great interest, and permit a critical examination much more readily than those relating to the intestines.

The first observation on flagellates in the urine is usually said to be that of A. Hill Hassall.[42]* An examination of Hassall's paper, however, makes it clear that his observations do not belong here at all. Hassall described the organisms he found under the name of *Bodo* Ehrenberg. The members of this genus have certain resemblances to trichomonas, but there are weighty reasons for believing that Hassall did not confuse the genera. In the first place he was familiar with Donné's figure, having copied it in his well-known work on microscopic anatomy (Vol. i, p. 134; Vol. ii, Plate xii., Fig. 6).[43] In the latter article he does not speak of trichomonas, as he would have been likely to do had he thought, as later authors have done, that he had found that parasite in the urine. More important still is his testimony regarding the vital characteristics of the so-called bodo urinarius. Hassall said this was "generated in urine which is alkaline, contains much animal matter, and which is, moreover, freely exposed to the air." The organisms appeared under the above conditions in three or four days, by which time trichomonads would have disappeared had they been present in the beginning. It is most probable that Hassall saw some infusorial monads, of no present importance whatever, and having no relation to human pathology.

In 1868, Salisbury[44] stated that "trichimonas *vaginæ* [*sic*—this form was used by some of the early writers] occurs occasionally in the bladder." Exact details are wanting.

Künstler, of Bordeaux, in 1883,[45] reported the first case in which flagellates were found in freshly passed urine. The case was one of pyelitis following cystotomy. In the copious sediment were bodies which Künstler thought might be cercomonads or the bodo urinarius of Hassall, although he remarked that they did not agree with Hassall's description. The bodies, he said, had two flagella, although at times it seemed as if three or four might be present. Künstler laid stress on the fact that the parasites came from the interior of the patient's body, where they lived in company with various bacteria. From the classification of Braun[49] (p. 108), it appears that Künstler at a later date assigned the parasites to the genus Plagiomonas Grassi. I cannot find a reference, and from the original description can see no reason for such a classification. Braun's statement that Blanchard called Künstler's parasite cystomonas urinarius I am also unable to verify. It remains doubtful whether Künstler's parasites were really trichomonads.

---

* This refers to human urine. From the time of Leeuwenhoek flagellates have been described, usually very vaguely, in the urine of lower animals.

Dr. F. Tilden Brown presented specimens and photographs of "ciliated infusoria in the urine" before the section of Genito-Urinary Surgery of the New York Academy of Medicine, December 12, 1893.[46] Dr. Brown has not yet reported the case in full, but from letters he was kind enough to write me, it appears that the organisms belong to the ciliata, and therefore do not come under consideration here. The observation is extremely interesting, inasmuch as it widens the horizon of the protozoan parasites of man.

The first undoubted case of trichomonas in the urinary tract of man is that of Marchand.[10]

> The host was a man, aged sixty years, who had a fistula in the perineum. The fistula followed suppuration in the pelvis, of seventeen years' duration, thought to be tuberculous. Pus appeared suddenly in the urine without symptoms of cystitis, so that rupture into the bladder was suspected. The general condition improved, but the urine remained turbid and was sent to Marchand for examination. It was acid and albuminous, with a copious, dirty-yellow sediment. In the sediment were numerous whitish particles, made up of epithelial cells of different kinds, hyaline casts, and red blood-corpuscles. Among the epithelial cells were curious hyaline bodies, larger than leucocytes, which proved on closer examination to be flagellates. The urine was examined daily for some time, but the occurrence and condition of the parasites was variable, so that it was with great difficulty that their nature could be made out. The fresh urine always contained numerous bacilli and cocci. Tubercle bacilli could not be found. The flagellates were almost exclusively in loose epithelial cell masses.

Marchand's description and figures leave no doubt that the parasites he found in this case are identical with those I found and reported later. As the result of comparative examinations of the parasites from the bladder and those in the vagina, Marchand concluded that there is at least a great resemblance if not identity. The former he found more hyaline, less plainly vacuolated, smaller, and more amœboid than trichomonas vaginalis. He doubted, with a caution unusual in the history of the intestinal flagellates, whether these differences suffice to prove different species, and thought they depended on the different media in which the organisms live. In a note to Miura's article, Professor Marchand says he thinks it probable the parasites lived in the urethra.

From the history given it seeems more probable there had been a rupture into the bladder, as supposed at first.

By a curious coincidence, a short time after publishing his own account, Professor Marchand received from Dr. K. Miura, of Tokio, the account in manuscript of another case in which trichomonads were found in the urine of a man.[47]

The patient was a Japanese, aged fifty-two years, with bronchitis and slight tenderness in the left renal region. The freshly passed urine, of yellow color and acid reaction, contained several thread-like particles and small bits. These were composed of round cells, colorless mucus, different kinds of epithelial cells, and flagellates. Miura examined the bodies with inadequate instruments, and his description of them is imperfect for that reason. He did not see all the flagella, although he was certain about the undulating membrane. He gave, however, other evidence as to the identity of the parasites. He found that most of the particles were passed with the first part of the urine, and by putting in a self-retaining catheter convinced himself that the organisms came from the urethra and not the bladder. The source of infection thus made probable was confirmed by examining the patient's wife, and finding in the vagina flagellate organisms resembling in form and size those in the urine of the man.

The next case, and only other, so far as I can learn, was one observed by myself and reported briefly in a preliminary note.[48]

The history is as follows: A. B., aged twenty-seven years, student. Father living and well. Mother died in childbirth. Patient was born in Illinois and lived there eleven years. Then lived near Gainesville, Texas, for thirteen years; in Oklahoma one year and a half; and in Bryan, Texas, one year. Since then has lived in Ann Arbor, with the exception of two months in Florida. As a child had measles, whooping cough, and scarlatina, without sequelæ.

For about nine years, while living in Texas, had malarial fever, usually of tertian type, sometimes quotidian. About 1884 had a "congestive chill" and was unconscious several days. Ever since then has had frequent urination. In the spring of 1892, while living at Bryan, Texas, had pneumonia. During convalescence painful and difficult urination came on, and after two days the urine became very bloody. This attack was considered one of malarial hæmaturia, and treated by quinine. The bleeding stopped, but difficult and painful urination continued. The symptoms became worse at irregular periods; they were made worse by "catching cold," by drinking whiskey in more than very small quantity, or by a change of drinking water. During the attacks patient has to urinate about every two hours. There is then pain in the left lumbar region and in the right groin, and at times pain radiating to the urethra. At the end of urination whitish particles are passed with the urine. They are more numerous two or three days after the attacks begin, but can be seen in the urine at all times. The urine has never had an ammoniacal color.

Patient denies venereal disease and coitus entirely. Smokes a good deal, drinks whiskey occasionally. Appetite good, bowels regular. Now feels fairly well, aside from the symptoms mentioned. Has lost about eight pounds in the last year. The patient has consulted many physicians, some of whom have examined the urine. They have usually made the diagnosis of gleet and advised instrumental treatment, but, as the patient knew he could not have gleet, he has always declined. A few days before I saw the patient his urine was examined by a colleague, who informed me that there was in it a good deal of blood and pus. Boric acid and salol were prescribed.

Status præsens. Man of tall and slender frame; muscles small, but firm; panniculus scanty; no œdema. Skin dark and sallow; extensive capillary nævi on face and body; mucous membranes healthy looking. Examination of lungs, heart, and abdomen negative. No enlargement of spleen or liver. Examination by rectum negative.

Patient passes 25 c.cm. of urine without difficulty, and in full stream. This is pale yellow, clear, but with a number of small whitish flakes about the size of pin-heads, and a small amount of clear mucus in the last part. The urine is acid, sp. gr. 1020; no sugar nor albumin. The particles mentioned look like caseous bits, but are less opaque. Microscopically they are made up of pus corpuscles, bladder epithelium of all kinds, and a number of bodies slightly larger than pus corpuscles, of a peculiar amyloid appearance.

It was very soon apparent (at the first examination) that these were animal parasites, and, as I propose to describe them in full later, I omit the notes made at the time, as well as the full notes taken from time to time after that.

October 25th. Examination of blood: Blood flows freely, of good color and consistence. Hæmoglobin (Fleischl), 100 per cent.; red blood-corpuscles (Thoma-Zeiss), 5,860,000; leucocytes, 8333. Red corpuscles are of normal appearance and form good rolls. Leucocytes show normal differential count. No parasites found in the fresh or stained blood.

From this time the patient remained comparatively free from symptoms, though the particles were passed as before. From gratitude at the improvement, and scientific zeal, he enabled me to examine his freshly passed urine at frequent intervals, sometimes daily, and to make all the necessary examinations, inoculations, etc.

I discovered very early that the particles are of two kinds. Some are small, or rarely long and narrow; opaque, with distinct outlines. These are made up of pus corpuscles (polynuclear neutrophile cells, with a few eosinophiles). They rarely contain parasites. The others vary in size, sometimes being two or three millimetres in diameter. They are less opaque than the others, sometimes quite gelatinous looking. They are composed of large squamous epithelial cells, transition cells of various sizes, a few leucocytes, and parasites in variable numbers. Once I counted three hundred and fifty parasites in a single particle, which, when spread under the cover-glass, measured about 3 mm. in diameter.

November 15th the patient caught cold at a foot-ball game. That night he had pain in the back and frequent urination. Next day the parasites were more numerous than they had been for some time. In the night of November 19th the patient went out to urinate. He felt a sharp pain in the penis, and on returning to the house found some blood on his shirt. The next morning I found two or three blood-spots on the shirt. The urine contained a few red blood-corpuscles; parasites as before.

From this time the history of the case has been much the same.

There have been no severe attacks of pain. The patient rarely has to get up at night. He has gained fifteen pounds, and says he feels better than at any time for ten years. The urine usually contains a few small particles, nearly always with parasites, but sometimes without any for several days at a time.

After a mild attack of influenza, during which the patient took salol and phenacetin, the parasites were more numerous, but the symptoms were not so severe as they had been after previous temporary illnesses.

When I first found the organisms I thought I had discovered a new species. The characteristic features of the bodies I saw were not mentioned as belonging to trichomonas in the hand-books in my laboratory and I was not familiar with the recent and more accurate investigations. Fortunately, I was able to demonstrate the first specimen found to my colleague, Dr. J. Playfair McMurrich, who at once determined the genus. This has been amply confirmed since then by the observations I have made and the examination of the literature of the subject. I have been able to demonstrate the parasites to a large number of my colleagues in the medical department and the department of animal morphology, and to exhibit them alive at a meeting of the Journal Club (biological) of the University.

As regards the species I am in the same position as Marchand. The parasites I have studied agree with his descriptions more than with any others. He found slight differences as compared with tr. vaginalis, but not enough to lead him to give a new specific name. I have not been able since I found the bladder parasite to make examinations of tr. vaginalis. I think it better, for that reason, to describe the parasites as fully as possible, leaving the question of classification to other observers or the result of future comparative examinations.

My own examinations have been very numerous, and included the observation of the parasites alive under various conditions for hours at a time, almost daily for long periods, the study of the effects of reagents, staining, cultures, and inoculations. My microscopic observations were all made with Zeiss D D., and one-twelfth-inch oil-immersion lenses.

ZOOLOGICAL CLASSIFCATION. Trichomonas belongs to the flagellate infusoria. In the classification of Bütschli, one of the most rational which has been attempted as regards the form we are now considering, it is placed in the sub-order Isomastigoda and family Tetramitina. This family includes the closely related *cercomonas* Davaine, and *trichomonas intestinalis* Leuckart, which Bütschli includes under the generic name *monocercomonas* Grassi. According to the same author, about three species of trichomonas are known. All are parasitic, living in the intestines of frogs, snails, and other lower animals, and in the human vagina.

Grassi, as mentioned before, includes some of the species in his genus *Monocercomonas*; others in that of *Cimænomonas*. *Trichomonas vagi-*

nalis, with which he was not familiar, he thought might belong in the family he called Trichomonadidea; this, and his description of that family, gives conclusive evidence that his statements regarding his unfamiliarity with tr. vaginalis are true.

In the latest classification, that of Braun (*loc. cit.*, p. 108), the genus *Trichomonas* includes *tr. vaginalis* Donné, and *trichomonas hominis* Davaine. The latter includes *cercomonas hominis* Dav.; *cerc. intest.* Lambl (1875), Marchand; *trichomonas intest.* Leuckart; and *monocercomonas resp. cimænomonas* Grassi.

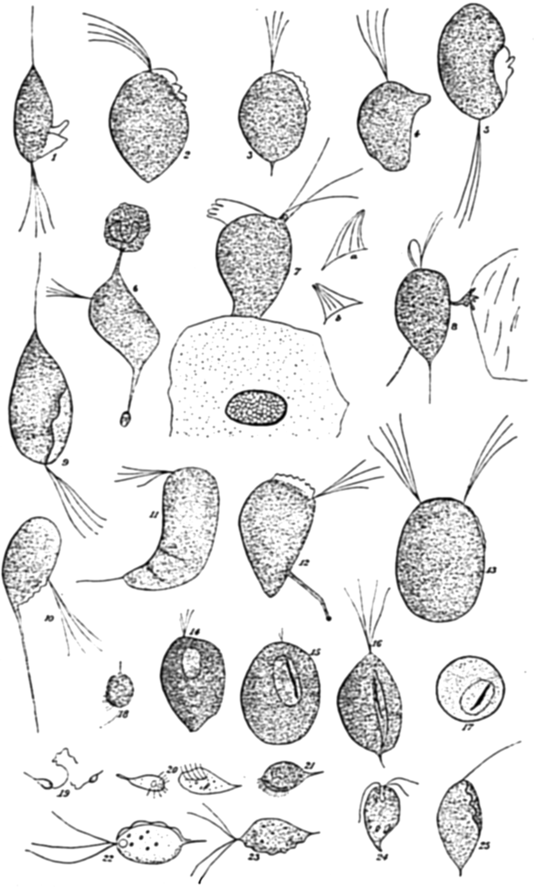
Evidently what is needed concerning the flagellate parasites is not so much classification and nomenclature as objective study. Braun deserves credit for restoring Donné's term, and is justified by the rule of priority, notwithstanding the imperfect description and etymological incorrectness of the French observer. The wisdom of including cercomonas in the same genus may be questioned.

SIZE, FORM AND STRUCTURE OF THE PARASITES. Trichomonas vaginalis is said by all who give measurements to be from 15 to 25 m mm. in length, 7 to 15 m.mm. in width. The organisms found by Marchand and Miura in the urine were about the same size. A number of measurements in my own case showed that most of the bodies are from 15 to 22 m.mm. in length and 10 to 15 m.mm. in width, but a few are considerably larger and some smaller.

The form of the organism also agrees with the descriptions of others. The commonest or typical form is a pyriform or broad spindle with one end rounded, or the shape of an apple-seed or almond-kernel. Sometimes the broad end is in front, sometimes behind. Sometimes the bodies are elliptical or oval; sometimes irregular (see figures). Donné early described changes of form like those in a leech. Without knowing that, I had compared the appearance to that of a garden slug. Occasionally, as will be described later, the form is altered as the result of special motion. Usually the smaller specimens are more typical in shape than larger ones. The bodies appear to be flattened from above downward.

The general appearance of the organisms is sometimes peculiar, so that they can be distinguished by tint or refraction before the characteristic organs are seen. Light and amplification have much to do with these things; in general the bodies are difficult to distinguish from leucocytes or other cells of similar size in the preparation until the motion of their peculiar organs is recognized. The outlines are usually sharp, the structure finely granular, sometimes hyaline and homogeneous, rarely coarsely granular.

The protoplasm is not easy to differentiate into separate parts. Künstler claimed for tr. vaginalis the existence of a cuticular layer,[6] in addition to an ectoplasm. Marchand also describes a similar



Figs. 1-13. Trichomonas from the bladder. Drawn from different live specimens as seen with Zeiss 1-12th inch immersion objective and No. 2 ocular. Drawn approximately to the same scale and enlarged in the plate. For details see text.

Fig. 14. As stained alive in watery methylen-blue solution. Fig. 15. After fixing with sublimate and staining with methylen-blue. Fig. 16. Fixed by sublimate; stained with acetic-carmine. Fig. 17. Late stage after treating with acetic-carmine. Fig. 18. Trichomonas vaginalis as depicted by Donné. After Hassall. Fig. 19. Cercomonas hominis. After Davaine. Fig. 20. Marchand's parasite from typhoid stool, 1875. Fig. 21. Zunker's parasite. Fig. 22. Trichomonas hominis. After Grassi. Fig. 23. Cercomonas coli hominis. May. Fig. 24. Trichomonas intestinalis (Marchand). After Roos. Fig. 25. Cercomonas hominis (Davaine). After Roos. Figures 18-25 are reproduced as nearly as possible in the sizes of the originals.

layer in the bladder parasite. I have never been able to demonstrate this, and the occurrence of pseudopods, to be described below, seems incompatible with a true cuticle. A differentiation into ecto- and endoplasm can, however, be made out, and the ectoplasm may in some cases simulate a cuticle. I have found the difference between the two layers well brought out by treating the organisms with (Gram's) iodine solution The endoplasm retracts slightly in some places, and stains deeply after considerable time, leaving a thin and faintly stained membranous layer outside. Both in unstained and stained specimens the inner layer of protoplasm has a finely vacuolated appearance when examined by high powers.

Small vacuoles or highly refracting granules can sometimes be seen in the bodies, but there is no contractile vesicle. This agrees with the statements of all who have examined tr. vaginalis. In the parasites I have examined I have never been able to recognize any particular inclusions such as bacteria, which others have found in tr. vaginalis. This may be due to the fact that the urine in my case seldom contained bacteria while under examination or while the parasites were still alive.

EFFECTS OF STAINS AND REAGENTS. The parasites are difficult and unsatisfactory to stain. The best results are obtained by staining alive, or by staining specimens recently killed by sublimate. Placed alive or after being killed by sublimate in methylen-blue solution, the parasites remain as clear bodies long after all other cells are deeply stained. Afterward the bodies become stained, and look coarsely granular or finely vacuolated according to the degree of amplification. In such preparations the nucleus appears as described below. Neutral-red is not as satisfactory as methylen-blue in staining live specimens. In dried preparations, fixed by heat, alcohol and ether, osmic acid, bichloride, or formalin, stains of all kinds are very unsatisfactory for the protoplasm, and usually also for the nucleus. In preparations fixed on the cover-glass, and stained by methylen-blue, a spiral line can sometimes be seen, extending from the insertion of the flagellum or near it, a variable distance backward. This has been noticed by others. I think it an artefact, as it is extremely rare.

Strong sublimate solution (5 per cent.) has the effect of rendering the organisms motionless at once and making their protoplasm more granular, no doubt as the result of coagulation. It often produces contraction in the bodies, and especially causes the appearance of two highly refracting lines nearly or quite parallel, and in a direction similar to that of the nucleus. These lines I am quite confident are the result of contraction. They appear also under the influence of acetic acid. Similar appearances have probably led to the idea of internal organs, or of a "rib," or "keel" in or on the body.

Acetic acid, besides bringing out the nucleus, clears up the protoplasm. Later the bodies become round and numerous granules can then be seen. These are often in rows or lines, but do not have a definite arrangement, as some authors have described in tr. vaginalis.

In unstained specimens the nucleus cannot be seen. Sometimes, with low powers, a bright or dark spot, depending on the focus, can be seen near the front of the body, as is also the case with cercomonas. This I think is only the effect of the refraction of the body. By the use of reagents, however, the nucleus can be plainly seen, and its characteristics examined. The nucleus is always in the anterior part, usually lying somewhat obliquely. Acetic acid brings out in this part a round or oval, highly refracting body, which comparative examinations prove to be the nucleus. It appears some time later than the nuclei of leucocytes or epithelial cells in the same preparation. Sometimes the highly refracting nucleus is enclosed by two lines, as mentioned in speaking of the protoplasm (Fig. 16).

In preparations stained with methylen-blue alive or after killing with sublimate, an oval area appears, sometimes with a dark vesicular outline, sometimes with a diffuse stain deeper than that of the protoplasm, but less granular. At other times a clear vesicle appears, and in it a long deeply stained body, the nucleolus of many writers, more properly spoken of as the chromatin-body. Around this is a clear area.

The nucleus is best demonstrated by staining live parasites in acetic carmine. This clears up the protoplasm, brings out the nuclear-membrane, and stains the chromatin-body deeply and distinctly. It then appears as a long and narrow, somewhat irregular body. The lines on both sides of the nucleus are present in the beginning, but after a few hours the bodies become round, the contents clear, with the nuclear membrane and chromatin-body, as in Fig. 17. The nucleus is about one-fourth to one-third the length of the body of the parasite.

At the anterior end of the organism are the flagella, concerning the history of which a few words are necessary. Donné described only one of these, but said it was sometimes bifurcated. Scanzoni and Kölliker saw two or three. Künstler was the first to claim that four was the constant number. This was denied by Blochmann and Bütschli, but confirmed by Henneguy, and Marchand found this number in both the vaginal and bladder parasites, but agrees with Künstler in saying that it is not always easy to recognize all four. After very extensive observations on this particular point I agree with Künstler. Often only one, two, or three flagella can be seen, even in a prolonged observation on the live organism. This is especially the case when the parasites are active. If, however, they are suddenly killed, as with saturated sublimate solutions, four flagella can be distinctly seen. In specimens which die naturally, or sometimes in those killed with iodine, it can be seen that one flagellum is thicker than the other one or two, as is not the case when all four are seen.

The length of the flagella in my examples varied from one to three times the length of the body. Usually these organs are about one and a half to twice the length of the body. The flagella seem to taper slightly from their insertion to the tips. Blochmann and Künstler have carried on an argument about the tapering of the flagella of tr. vaginalis, and Künstler, who asserts that they taper, admits that the appearance may be the result of transparency. (See Bütschli, *loc. cit*, p. 673.)

The flagella usually rise so close together that they seem adherent at the base, or to arise from a common pedicle. That they do not do this I am convinced by finding them separated at the base by a short pseudopod (Fig. 7) in one instance. Künstler held that the flagella arise from a sort of "rostral prolongation" of the body, a view which Marchand seems to support. In my own case I could find no evidence of it. The flagella have very clear outlines and a fine homogeneous structure. I could never see any evidence that they are sticky, as are the flagella of some other protozoa. I have made many efforts to stain the flagella, but without satisfactory results.

The posterior end of the body is sometimes prolonged into a long tail-like process. Donné no doubt saw this, as he said that the organisms fix themselves to the cover-glass, "not by suckers, but by a sort of viscous material which leaves a trail behind it." This appearance I have often seen. It seems to be due to the formation of a thin, soft, adhesive pseudopod. At other times a sharply-outlined tail is present, which may resemble a flagellum, but usually differs in its more granular structure and its less distinct outline, and also by its lack of flagellar motion. It is, moreover, capable of marked change of form, and is often retracted, or contracted and expanded, showing its close relation to pseudopodial structures. The tail is likely to be adherent to various objects in its vicinity—leucocytes, other parasites, or granules of broken down leucocytes. Not infrequently one can see two parasites attached by the tails, which often show curious changes of shape. This has led some to think the organisms undergo transverse division, but I have never been able to find evidence of the earlier stages of such a process. The most remarkable thing about the tail is that it may be absent from all the organisms examined for many days, and then be found on almost all examples in another specimen, so that when one finds one parasite with a long tail it is safe to predict that most of them will have them. In such cases a preparation containing a number of parasites presents a curious appearance, as if full of gigantic spermatozoa. It may be necessary to add that no error can be made between these two objects if one has other guides to the size of the organisms, as leucocytes in the field, or familiarity with the microscope, so that the grotesque figures in a recent work on *Medical Jurisprudence* are not necessary in order to avoid confusion.

The most interesting part of the parasite, in many ways, is the undulating membrane. Donné thought the organism he discovered had a row ot short cilia on one side, near the anterior end, and this error was handed down from one observer to another, until Künstler confirmed Stein's assertion, based on the relations in the trichomonas of the frog, that the so-called ciliary comb was an undulating membrane. The discovery of Künstler was confirmed by Blochmann and Bütschli. In my own case, although usually visible, in some examples the undulating membrane could never be seen, so that I think it can be temporarily absent. I found it absent usually in those parasites which exhibited most marked change of form, and it seems probable that there may be some relation between the two things, so that one function can replace the other under certain circumstances. Stein was of the opinion that the undulating membrane of trichomonas is not a permanent structure, in fact not a true membrane, but is due to the alternate projection and retraction of a part of the body; but this is denied by Bütschli. Opinions differ as to the extent and insertion of the membrane in tr. vag. Künstler claimed that the membrane passes around the body of the parasite in a spiral line, being inserted in a sort of rib, but he admitted that it is only by a "lucky chance" that one can see the whole membrane. Blochmann, however, thought the membrane half as long as the body, and in this Marchand agrees with him.

I have never found the membrane more than two-thirds the length of the body, extending from the insertion of the flagella backward; often it is much shorter. The membrane is sometimes on one side of the body, sometimes the other. It may extend out from the side of the body or be turned over or under it, or it may arise from a straight or spiral line on the anterior surface of the body, facing the observer. No distinct line, ridge, or depression can be seen at its origin, and it often gives the impression of a gradual thinning out of the side of the parasite. The membrane varies much in width, and this variation is independent of the shape of the body. The outer edge of the membrane is sometimes thickened and so resembles a flagellum, but this is not constant. Very rarely have I been able to see the membrane prolonged to a point. Usually the posterior end tapers gradually to the side of the parasite. Owing to the fact that the outer edge is much longer than the insertion, the undulating membrane is always more or less zigzag, fluted, or scalloped, so that from the folds and the zigzags the appearance of a row of cilia is often very closely simulated. The membrane does not stain well.

The organisms I have seen have no signs of mouth or other digestive organs. Donné thought there probably was a mouth, but did not assert it as a fact, as has been claimed. Blochmann and Bütschli could not find one. Künstler claimed to find mouth and œsophagus, and claims that Gasser (*loc. cit.*, p. 35) described the mouth as a *cavité cupuliforme.* Marchand could not find it in live specimens, but in stained ones he saw tubular structures extending forward from the nucleus. I believe that some observers have mistaken the appearance produced by the undulating membrane, as it plays along the middle of the body, for the mouth. In such a case a narrow clear space appears to be in the body at that part. Another thing which Donné perhaps thought was the mouth I have often seen. This is a shallow depression or cleft near the insertion of the flagella, which no doubt has the function of a mouth. At times one side keeps up a nibbling motion, which is very suggestive of a mouth. The appearance is not permanent, however, and is rather uncommon.

PHYSIOLOGICAL CHARACTERISTICS. The phenomena of motion presented by trichomonas are extremely interesting. The simplest is due to contractions of part of the body, with change of form, as Donné mentioned. This enables the organisms to change their position to a considerable extent, so that in a few minutes one may move across the field. Such extensive motion, however, is unusual, and the process is generally limited to jerking movements of the body in different directions.

Another process consists in the projection of lobes, usually combined with contractions, so that amœboid motion is simulated. True amœboid motion, in which, along with a projection of the ectosarc there is a flowing in of the endosarc, I have not seen, and the changes of form and position are never so great as in typically amœboid organisms. That this function indicates the existence of a cuticular membrane is not a necessary conclusion, as some zoölogists have claimed, but it can be brought about by contractions of the outer layer of the plasma or of the plasma as a whole (Bütschli, *loc. cit.*, 849). I have also seen another process, mentioned by Blochmann and by Künstler. This consists in the appearance of a scalloped edge on one side the body, with a wave-like motion running along it. I have only seen this in dying organisms and take it to be peculiar to that stage.

Another function exhibited by trichomonas consists in the formation and motion of pseudopods. My observations indicate that this is an important function. Künstler and Marchand seem to be the only observers who have noticed pseudopodial formation in trichomonas, but I have been fortunate in seeing it oftener and more specialized than they seem to have done. It can occur in any part of the body. In the simplest form short knob-like projections appear on the body. (Fig. 7.) Much more frequently a long narrow process is formed, usually becoming fixed to something in the vicinity. (Figs. 6, 8, and 10.) Pseudopods of this kind often serve as organs of support. So in the parasite from which Fig. 12 was taken, the end of the process was fixed to the cover-glass like a sucker. The animal then made rapid and abrupt bobbing movements resembling a duck diving for food. The pseudopod at such times bent at an angle, always in the same place. The body of the parasite at the same time changed its shape considerably, so that the undulating membrane, which, at first, ran down over the back, came to be in front. At times a tail was present. At the anterior end a cleft often formed, and exhibited the nibbling motion in its sides, as mentioned above. The flagella and membrane were in active motion all the time. The narrow pseudopods expand and contract at times in different parts. The most remarkable pseudopodial action I have seen is depicted in Fig. 8. A similar process was seen several times. Here a pseudopod was passed over or under the side of an epithelial cell. The end then expanded and became branched, resembling a very irregular minute amœba. The lobules of the extremity then kept up a constant and somewhat rapid amœboid motion, resembling precisely that of an endoglobular malarial parasite. Sometimes the ends kept up a rhythmic motion, giving a revolving effect. This pseudopodial function seems to be an important one in the nutrition of the parasite, especially when for any reason the flagella and undulating membrane cannot act.

The motion of the flagella is whip-like usually, but, at times, spiral, the waves always running from the insertion to the tip. Motion is not directed always in the same direction, as claimed by some in the case of trichomonas vaginalis. Sometimes the motion is toward the side of the undulating membrane, again toward the opposite side. Usually it is directly forward. Sometimes one flagellum has a different direction from the rest, bending down along one side, or across the body. Sometimes a flagellum turns down along one side, and, without touching anything, acts as a point from which the whole body moves, apparently as the result of a powerful action of the flagellum. By their ordinary motion the flagella produce a current toward their insertion, causing granules in the fluid to shoot with great velocity against the anterior end of the body. At such times the appearance of a mouth is often produced, the granules apparently being taken in by stomata which form and disappear.

The motion of the undulating membrane is usually a waving one from before backward, due to the ciliary motion of the edge; sometimes the motion is apparently spiral. The rapidity of the motion varies very much, and this, with the difference in the width of the membrane, gives great variety to the appearances presented. Sometimes close folds are produced, sometimes zigzags advance and retract along the edge, and often the membrane seems to be actually revolving, like the arms of a windmill. Sometimes the general direction of the membrane is greatly altered, as shown in Fig. 7, *a* and *b*.

The membrane also produces a current which runs toward the anterior end, carrying floating granules with it.

That the membrane, as well as the flagella, acts as an organ of locomotion seems likely, but I have never seen it. Even in the hanging drop on the warm stage I have never seen the parasites swimming freely. In this respect they offer a marked contrast with cercomonas Davaine. According to Künstler the undulating membrane acts as a locomotor organ when the parasites are closely surrounded, enabling them to move as a serpent does.

The trichomonas, as I have found it, is extremely sensitive to external conditions. Kept in an incubator, in the urine as passed, the parasites remain alive and active for six or seven hours. In the usual room temperature they die an hour or two earlier. Organisms dying in this way often show a few short, straight, hair-like processes on various parts of the body. These are not bacteria, but are most probably like the similar processes sometimes present on dead or dying cells of various kinds.

If a preparation containing parasites is examined from time to time without allowing it to evaporate the organisms completely disappear, and nothing remains that can be recognized as derived from them. The same is true of specimens kept in an incubator for twenty-four hours or more.

Cold is injurious to the organisms, so that on the slide in a cold room little or no motion is seen, but if the room is warmed, or the preparation put on a warm stage, motion soon becomes active. All the phenomena of motion are marked at a temperature of 80° F., more active still at 98°, but cease in a few minutes if the warm stage is heated up to 120°.

When the organisms are becoming sluggish from long stay out of the body they cannot be revived by heat. The addition of dilute alkalies, which stimulates some protozoa, has no effect on them, but stronger solutions are injurious.

The organisms occur always, as I have said before, in acid urine. Künstler has called attention to the fact that trichomonas vaginalis also lives in an acid medium, a fact on which Donné laid considerable stress, and which seems to have few exceptions, Haussmann saying they occur in alkaline secretions, though not in large numbers.

As the parasites are anærobic—as Künstler showed tr. vaginalis to be—I made an effort to grow them in that condition. I was fortunate in getting my friend, Dr. F. G. Novy, to make some trials with the admirable apparatus devised by him (*Centralblatt für Bakt. und Parasit.*, 1893, Bd. xiv. p. 581). We tried urine, as well as numerous culture solutions, but without effect. The parasites disappeared just as they did when exposed to the air.

Mercuric chloride kills the motion and at the same time fixes the organisms. Compound solution of iodine also stops motion of all kinds at once.

When the bodies are dropped into saturated solution of sulphate of quinine the motion of the flagella and of the undulating membrane stops at once. In a few (three) minutes the bodies swell out and become clear, with bright granules scattered through them, sometimes arranged in lines. The bodies are very soft, as shown by the indentation produced by other bodies pressing on them. A little later the flagella and undulating membrane begin a spasmodic jerking motion. The bodies become larger and larger, the undulating membrane very narrow. Hyaline vesicles break out from the sides of the swollen bodies. The motion of the flagella sometimes lasts for an hour, by which time, however, the bodies are usually only large collections of clear vesicles. The process here seems partly poisonous, partly due to imbibition as the result of paralysis. Water alone does not produce the vesicular change so rapidly.

Salicylic and boric acids cause similar changes. No appreciable difference in rapidity can be seen in the action of these various drugs.

Efforts to grow the organisms in the bodies of animals failed. I first tried the vagina and bladder of guinea-pigs and rabbits. As the urine of these animals is very alkaline I used a large bitch. After the first trial under chloroform it was possible to catheterize the animal without an anæsthetic, so that the experiment was quite simple. Although a vaginitis and mild cystitis occurred from intentional irritation with the end of the (glass) catheter, no flagellates appeared as the result of numerous injections of epithelial bits containing active parasites. The dog's urine, however, though acid, is not identical with that of man, so that I do not consider the experiments very conclusive. Experiments on man could not be made.

Reproduction. It is generally admitted that all flagellates multiply by longitudinal division, although some have other methods besides. Künstler and Marchand have observed longitudinal division in tr. vaginalis, the latter finding frequent evidence of it. In my experience the process has been very rare. I have seen it only twice, once in a preparation stained by acetic carmine, and once in a live specimen. (Fig.| 13.) In the latter, a very large body, there were two sets of flagella and two undulating membranes, one being between the sets of flagella. In trying to stain the organism alive I lost it. (It might be thought that this figure represents a copulation-process. From what we know of this among the flagella, however, such is not the case.)

Of the formation of "dauer" spores, etc., in trichomonas, nothing is known, but from the number of parasites often present in my case and the scarcity of dividing bodies it seems there must be some other method of reproduction than that by division.

MODE OF INFECTION BY TRICHOMONAS. From our present knowledge of the distribution of trichomonas it is impossible to explain its mode of entrance in man. The most probable explanation is that it exists in some other form, perhaps in water or on plants, and gains entrance to various animals in that way. The theory of Cunningham that both cercomonads and trichomonads are nothing but zoospores of amœbæ, inviting as it is, has not been confirmed. Perroncito,[50] who has made a special study of cercomonas, claims that it becomes encysted, forming "dauer" forms, which are more resistant to external influences than the active forms, and are readily transported, and so enters the human body. May thought his patient had been infected by drinking-water, and Epstein brings almost conclusive proof that the organisms found by him entered the body in the drinking-water. He noticed, for example, that sucklings who never drank water never had the protozoan diarrhœa. At one time three children in one room got the disease simultaneously. A fourth child in the same room, by reason of his condition, drank no water. After demonstrating that the stools of this child were free from flagellates, he was given in the course of twenty-four hours 250 c.cm. of water from the pump from which the other children were supplied. On the same day flagellates appeared in the stools, which soon became watery, were forcibly ejected, and later showed large numbers of parasites. The so-called monocercomonads could not be found in the water, nor any form with which they could be supposed to have relationship. (It is an interesting fact that the water in question came from the pump used by the patients with amœbic dysentery reported some years ago by Hlava.[51] Epstein makes the important statement that amœbæ have been found in that water.)

It is, of course, possible that the water contained organisms in numbers too small to enable them to be discovered. Whether that is true, or that the organisms existed in the water in another form, their prompt appearance in the stools of Epstein's patient is a noteworthy fact, indicating rapid reproduction under favorable circumstances. It is easier, however, to imagine how organisms of this kind can enter the intestine than to explain how they enter the vagina, especially since injections of ordinary water kill the developed forms. Balbiani (cited by Henneguy[7]) thinks that the flagellates may be swallowed in water, set free in the intestine, and wander from the anus along the perineum into the vagina, as does oxyuris. If Schuberg is correct in thinking the flagellates almost constant inhabitants of the intestine, this theory would have much in its favor.

In the cases in which flagellates were found in the urine of men the question as to mode of entrance is extremely interesting. In Künstler's case one can suppose the organisms came from the intestine and gained entrance to the bladder through the perineal wound. If in Marchand's case there really was a rupture of the intestine into the bladder, as the history makes probable, we should have important evidence regarding the intestinal flagellates, as well as a ready explanation of the mode of infection. If, on the other hand, as Marchand thinks, there was an infection of the urethra, as happened in Miura's case, the manner of infection is clear, but the question arises why such urethral infection is not more frequent in places where trichomonas vaginalis is as frequent as some authors have found it. (Scanzoni and Kölliker in more than half, Haussmann in as many as forty per cent. of women examined, Künstler in nearly all women who had leucorrhœa and did not use injections.)

In my own case the relations seem to be unique. Not only the assertions of the patient, but also the characteristics of the urine, exclude infection by the urethra, and I think we must admit that the parasites reached the urinary tract indirectly. Such an event is, of course, no more remarkable in itself than many well-established facts in pathology.

PATHOLOGICAL IMPORTANCE OF THE FLAGELLATES. The question remains, have the organisms under discussion any pathogenic powers or are they simple "commensals?"

When Donné first reported the existence of trichomonas vaginalis he thought it characteristic of venereal blennorrhagia, though he did not commit himself to the belief in its casual relation. Later, he thought the organism had no specific importance, as he found it in muco-purulent discharges due to irritants of all kinds, *e. g.*, pessaries. Scanzoni and Kölliker thought the parasites had no specific action, but believed they were never found in the normal vaginal secretions. Künstler thought they must have pathogenic action, but not of a specific kind. The prevalent opinion among recent writers is that the organisms are accidental parasites in the vagina and mere "commensals." Here, of course, the organisms are never alone, but always accompanied by bacteria, many of which are pathogenic, so that it is impossible at present to assert that the animal parasites produce the disease with which they are associated. This does not imply that they have no pathogenic action.

As regards the intestinal parasites, the general opinion is that at the most the flagellates can by their presence keep up a diarrhœa which furnishes favorable conditions for their development. Many writers, especially Cunningham, Grassi, and Schuberg, think the organisms common parasites of the intestine. The clinical observations of Epstein, however, show that at least some of the intestinal flagellates can produce diarrhœa in man, and Perroncito (*loc. cit.*) claims that a species of intestinal cercomonas causes a fatal disease in guinea-pigs.

In the cases of Künstler, Marchand, and Miura the flagellates were associated in the urine with bacteria, so that no conclusion can be drawn as to their relation to disease.

In my own case the conditions were simpler and seem to me to require a revision of the whole subject.

The patient has had for some months, while under observation, a peculiar pathological process in the urinary tract, presumably in the bladder. It is probable the condition has existed for many years. This process is distinguished by an exudation of leucocytes and a desquamation of epithlial cells such as occurs in many cases when there is local disease in the organs concerned. So, for example, a tubercular nodule, a localized gonorrhœal infection might have such results. In this case, however, there is no sign or history of stone and no sign of bacterial infection. Culture experiments, repeated under various conditions, ærobic and anærobic, show no bacteria at all, and bacteria are invariably absent from cover-glass preparations when pains are taken to exclude contamination from the outside of the body. I am therefore forced to the conclusion that the parasites have produced the anatomical alterations, the evidence of which is so clear.

There is another feature which deserves consideration—the hæmaturia. Although this has not been excessive since the patient came under my observation, it has at least been at times out of proportion to the exudation. It must be remembered that since the patient has been under my care remedies have been used, more or less regularly, which must have a harmful effect on the parasites and lessen their activity.

I have in another place (*Hare's System of Practical Therapeutics*, vol. ii. p. 356) expressed my doubt regarding the malarial nature of certain cases of hæmaturia occurring in the Southern States. When in Texas, besides cases of undoubted malarial hæmaturia, I saw others which showed no evidence of malaria. It is well known that there is an apparently endless controversy regarding the treatment of such cases, a fact in striking contrast to the conditions in other malarial diseases. I did not see these cases under circumstances favorable for investigation, however, and often had to be satisfied with the examination of specimens sent a long distance. I suggested that some of these cases might be due to filaria or to Bilharzia, although I could find no positive evidence. In the light of the case now reported I do not think trichomonas can be left unconsidered in future investigations on this important subject.

In connection with this it is interesting to recall the cases in which amœbæ were found in the urine, reported by Baelz,[52] Jürgens,[53] Kartulis,[54] and Posner.[55] These are important clinically and anatomically because in three cases there was hæmaturia, and in the fourth (Jürgens), the clinical details of which are wanting, hemorrhagic lesions in the bladder. This was the only case in which an autopsy was obtained. (Posner's case was the only one remaining alive.) Jürgens found small cysts in the thickened bladder-wall full of amœbæ. In Posner's case there were evidences that the kidney was affected, without signs of disease of the bladder. Posner thought the amœbæ had become encysted in the kidney, and so caused hæmaturia and nephritis. In this case, the only one observed for more than a short time, the patient had five attacks of hæmaturia in the course of several months. In the case of Baelz, a girl with tuberculosis of the lungs and genito-urinary tract, amœbæ were found in the vagina, and the observer thought they had entered that organ in washing, increased there, and then gained entrance to the urethra and bladder. In Jürgens's case, also a woman, bodies were found in the vagina which seemed to be earlier forms of the parasite. Posner thought that in his patient, a man, the parasites had entered the urethra and travelled up.

Two things must be borne in mind in considering the pathological relations of trichomonas. In the first place, we cannot assume that this is a harmless parasite always, because of its occurrence in comparatively mild diseases of the vagina and intestine, for organisms innocuous on such surfaces might in the bladder, ureter, or kidney set up severe or dangerous processes. Here I recall the finding of several hundred parasites in one small bit of epithelium on one occasion, strongly suggestive of cysts such as Jürgens found in his amœba case.

In the second place, we must remember that this parasite is not necessarily as rare as the few cases reported might seem to indicate. The history of the amœba coli and that of the malarial hæmatozoon show the need of caution in this respect, and the trichomonas, like the other organisms just mentioned, can only be found if the substance containing it is examined under favorable conditions. That I found the bodies I attribute to the effort I always make to examine urine as soon as passed, a practice of great value in many ways. Experienced microscopists had examined the same case, but without taking that precaution, and without success.

The precise place of trichomonas in pathology can of course be fixed only by further observation and experiment. If I am wrong in attributing to it a pathogenic power it does not possess, I feel that my observations on it have at least some value as a contribution to the biology of the flagellate protozoa.

BIBLIOGRAPHY.

1. *Donné, L.:* Animalcules existant dans certaines matières purulentes. Comptes Rendus de l'Académie des Sciences, 1836, tome iii. p. 385.

—— Recherches microscopiques sur la nature des mucus, etc., Paris, 1837.

—— Cours de Microscopie, Paris, 1844.

2. *Scanzoni and Koelliker:* Das Secret der Schleimhaut der Vagina und des Cervix Uteri. Beiträge zur Geburtskunde, Bd. ii. 1855.

3. *Hennig:* Der Catarrh der inneren weiblichen Sexualorgane, Leipzig, 1862.

4 *Haussmann:* Die Parasiten der weiblichen Geschlechtsorgane, Berlin, 1870.

5. *Gasser:* Les parasites des organes génitaux de la femme, Paris 1874.

6. *Künstler, J.:* Comptes Rendus de l'Académie des Sciences, 1883, tome xcvii. p. 755.

Künstler: Journal de Micrographie, Paris, 1884, vol. viii. p. 317.

7. *Henneguy:* Dictionnaire encyclopédique des Sciences médicales, 1885, tome 97. *Art.* Trichomonas.

8. *Blochmann:* Zeitschrift für wissenschaftliche Zoologie, 1884, Bd. xl. p. 42.

9. *Bütschli:* Bronn's Klassen und Ordnungen des Thierreichs, Bd. i. Protozoa; Abtheilung ii. p. 676, etc.

10. *Marchand, F.:* Ueber das Vorkommen von Trichimonas im Harne eines Mannes, nebst Bemerkungen über Tr. vaginalis. Centralblatt für Bakteriologie und Parasitenkunde, 1894, Bd. xv. p. 709.

11. *Dujardin:* Histoire naturelle des Zoophytes Infusoires, 1841.

12. *Perty:* Zur Kenntniss kleinster Lebensformen nach Bau; etc., Bern., 1852.

13. *Davaine:* Traité des Entozoires, Paris, 1877.

14. *Stein:* Die Organismus der Infusionthiere, Leipzig, 1878.

15. *Davaine:* Comptes Rendus de la Société de Biologie, Paris, 1854; 2 série, tome i. p. 129.

16. *Dock:* Observations on Amœba Coli in Dysentery and Abscess of the Liver. Texas Medical Journal, April, 1891.

17. *Ekecrantz:* Virchow-Hirsch's Jahresbericht, 1869, Bd. i. p. 202.

18. *Tham:* Ibidem, 1870, Bd. i. p. 314.

19. *Cunningham:* On the Development of Certain Micro-organisms Occurring in the Intestinal Canal. Quarterly Journal of Microscopic Science, 1881, vol. xxi.

20. *Grassi:* Sur quelques Protistes endoparasites, etc. Archives Italiennes de Biologie, 1882, vol. ii. p. 402; 1883, vol. iii. p. 23.

21. *Von Jaksch:* Ueber das Vorkommen von thierischen Parasiten in den Fæces der Kinder. Wiener klin. Wochenschrift, 1888, No. 25.

22. *Müller:* Centralblatt für Bakteriologie und Parasitenkunde, 1890, Bd. viii. p. 592.

23. *Massiutin:* Ibidem, 1889, Bd. vi. p. 451.

24. *Kartulis:* Zur Ætiologie der Dysenterie in Ægypten. Archiv für path. Anatomie, etc., 1886, Bd. cv.

25. *Cahen:* Ueber Protozoen im kindlichen Stuhle. Deutsche med. Wochenschrift, 1891, No. 27.

26. *Lutz:* Zur Kenntniss der Amœben-Enteritis und -Hepatitis. Centralblatt für Bakt. und Parasitenkunde, 1891, Bd. x. p. 242.

27. *Councilman and Lafleur:* Amœbic Dysentery. The Johns Hopkins Hospital Reports, December, 1891, vol. ii. Nos. 7, 8, 9.

28. *Schuberg:* Die parasitischen Amœben des menschlichen Darmes; Kritische Uebersicht. Centralblatt für Bakteriologie und Parasitenkunde, 1893, Bd. xiii.

29. *Lambl:* Mikroscopische Untersuchungen der Darm-Excrete. Vierteljahrschrift für die praktische Heilkunde, 1859, Bd. 61.

30. —— Cercomonas et Echinococcus in hepate hominis. Russian Medical Reports (Russian), 1875, No. 33.

31. *Marchand:* Ein Fall von Infusorien im Typhus-Stuhl. Archiv für path. Anat., etc., 1875, Bd. lxiv. p. 293.

32. *Zunker:* Ueber das Vorkommen des Cercomonas intestinalis im Digestionscanal, etc. Deutsche Zeitschrift für praktische Medicin, 1878, No. 1.

33. *Leuckart:* Die Parasiten des Menschen, 2 ed., Bd. i. p. 315.

34. *May, Richard:* Ueber Cercomonas coli hominis. Deutsches Archiv für klinische Med., 1892, Bd. 49, p. 51.

35. *Roos:* Ueber Infusoriendiarrhœ; Ib. 1893, Bd. 51, p. 505.

36. *Epstein, Alois:* Beobachtung über Monocercomonas hominis (Grassi) und Amœba coli (Loesch) bei Kinder-Diarrhœn. Prager med. Wochenschrift, 1893, Nos. 38, 39, 40.

37. *Lenhartz:* Mikroscopie und Chemie am Krankenbette, p. 61.

38. *Kannenberg:* Ueber Infusorien im Sputum. Archiv für path. Anatomie, 1879, Bd. lxxv. p. 471.

39. —— Ueber die Infusorien in den Sputis bei Lungengangrän. Zeitschrift für klin. Med., 1880, Bd. i. p. 228.

40. *Streng:* Infusorien im Sputum bei Lungengangrän. Fortschritte der Medicin, 1892, Bd. x. p. 757.

41. *Litten:* Ueber Hydropneumothorax und das Auftreten von Cercomonaden im lebenden Lungengewebe Verhandlungen der Congress für innere Medicin, 1886, p. 417.

42. *Hassall, A. Hill:* On the Development and Significance of Vibrio Lineola, Bodo Urinarius, etc. The Lancet, London, 1859, ii. p. 503.

43. —— The Microscopic Anatomy of the Human Body in Health and Disease, London, 1849.

44. *Salisbury:* The American Journal of the Medical Sciences, April, 1868, p. 377.

45. *Künstler:* Analyse microscopiques des urines d'un malade atteint de pyélite consécutive à une opération de taille. Journal de Médicine de Bordeaux, 1883–4, vol. xiii. p. 249.

46. *Brown, F. Tilden:* Ciliated Infusoria in the Urine. Journal of Cutaneous and Genito-Urinary Disease, 1894, p. 81.

47. *Miura:* Trichomonas vaginalis im frischgelassenen Urin eines Mannes. Centralblatt für Bakt. und Parasit., 1894, Bd. xvi. p. 67.

48. *Dock:* Flagellate Protozoa in the Freshly-passed Urine of a Man. The Medical News, 1894, ii. p. 690.

49. *Braun, Max:* Die thierischen Parasiten des Menschen, 2 ed.

50. *Perroncito:* Ueber die Art der Verbreitung des Cercomonas intestinalis. Centralblatt für Bakteriologie und Parasitenkunde, 1888, Bd. iv. p. 220.

51. *Hlava:* Centralblatt für Bakt. und Parasit., 1887, Bd. i.

52. *Baelz:* Ueber einige neue Parasiten des Menschen. Berliner klinische Wochenschrift, 1883, p. 237.

53. *Jürgens:* Verhandlungen des Vereins für innere Medicin. Deutsche med. Wochenschrift, 1892, p. 454.

54. *Kartulis:* Ueber pathogene Protozœn bei dem Menschen. Zeitschrift für Hygiene, 1893, Bd. xii. p. 1.

55. *Posner:* Ueber Amœben im Harn. Berliner klin. Wochenschrift, 1893, p. 674.

CRANIOTOMY (CRANIECTOMY) FOR IDIOCY.

BY CHARLES L. DANA, A.M., M.D.,
OF NEW YORK.

It is with some hesitation that I present the subject of craniotomy for the relief of idiocy and imbecility, for I find that the operation is not approved of by many, and has in a considerable degree fallen into disrepute and disuse. At the last meeting of the Congress of German Surgeons, Professor Bergmann, in his address on "Brain Surgery," made no mention whatever of this operation. At the last International Congress, Professor Jacobi, under the title *Non Nocere,* protested in vigorous language against the tampering by surgeons with the skull-caps of idiots. Quite recently Dr. Barbour, of Louisville, read a paper before the Louisville Medical Society on "Linear Craniotomy." He drew some unfavorable conclusions, and concluded with the Biblical injunction, *Mene, mene, tekel, upharsin.* Dr. Vance, in the subsequent discussion, stated that "the bottom had fallen out of the operation." Some two years ago Bournville, of Paris, published a long and elaborate article in which he showed, with a degree of explicitness quite unnecessary, in my opinion, that craniotomy does not and cannot affect the development of brains in which there are large cysts or in which portions of the brain are replaced by fibrous scars and sclerotic overgrowth.

All this would surely be sufficient to deter one from further study or practical utilization of craniotomy if it were not that certain other facts exist which must still be taken into consideration. It has so happened that in my personal experience I have seen idiotic and epileptic chil-